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BARBER COLMAN

# INSTRUCTION MANUAL

BARBER-COLMAN COMPANY
Industrial Instruments Div. • Rockford, Ill., U.S.A.

1211.6
IN 3-2

MODEL 477P CAPACITROL

# INTRODUCTION

This instruction manual is designed to help you secure maximum benefits from your new Model 477P Capacitrol. It should be given to persons responsible for installation, operation and maintenance of this instrument.

Your Barber-Colman factory trained field engineer is always available for further help in the solution of your control problems. Offices are located in all principal cities.

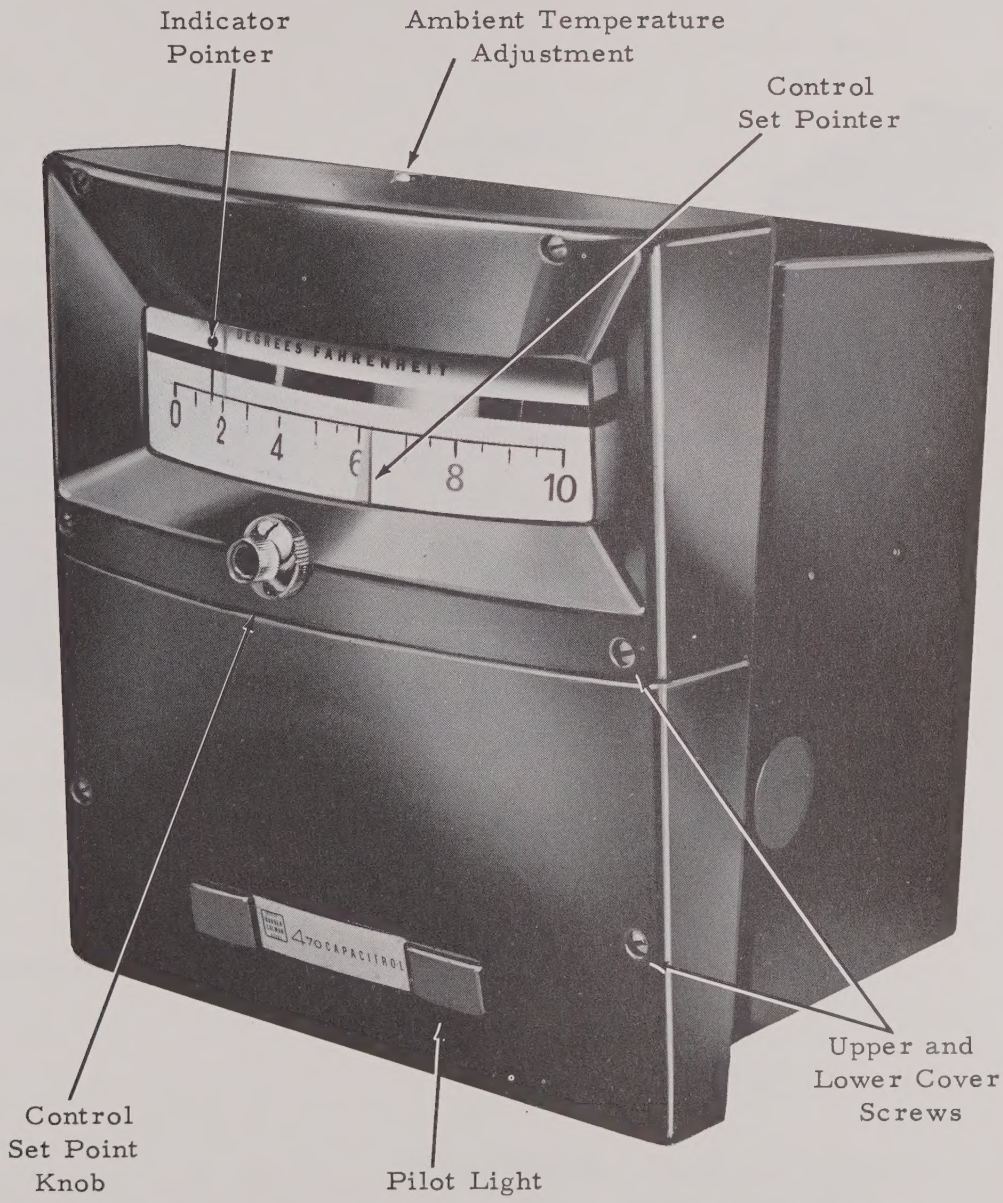
BARBER-COLMAN COMPANY
Industrial Instruments Division

Litho in U.S.A.

September 1966

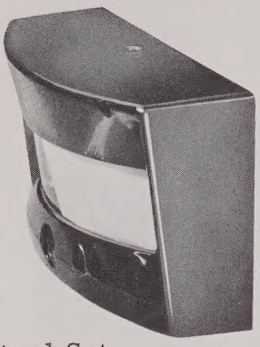
TABLE OF CONTENTS


| | Page |
|---|---|
| Illustrations | i |
| Specifications | iii |
| Description | |
| General Description | 1 |
| Control Specifications | 1 |
| Description of Electronic Circuit | 1 |
| Proportional Control | 2 |
| Installation and Start-Up | |
| Unpacking the Instrument | 5 |
| Mounting Instructions | 5 |
| Power Wiring | 5 |
| Mounting Dimensions | 6 |
| External Wiring Diagrams | 7 |
| Meter Shunt Wire | 12 |
| Thermocouple Wiring | 12 |
| Thermocouple Break Protection | 13 |
| Thermocouple and Leadwire Resistance Compensation | 16 |
| Cold Junction Compensation | 16 |
| Operation | |
| Control Action | 19 |
| Control Adjustments | |
| Proportional Band Adjustment | 19 |
| Reset | 20 |
| Maintenance | |
| Routine Servicing | 21 |
| Measurement or Control Trouble | 21 |
| Calibration Check | 22 |
| Internal Wiring Diagrams | 24 |
| Replacement Parts List | 26 |
| Suggested Repair Parts | 28 |



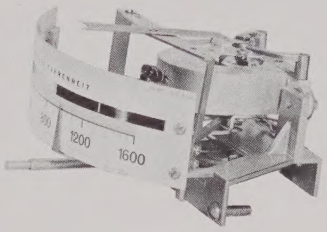

MODEL 477P CAPACITROL

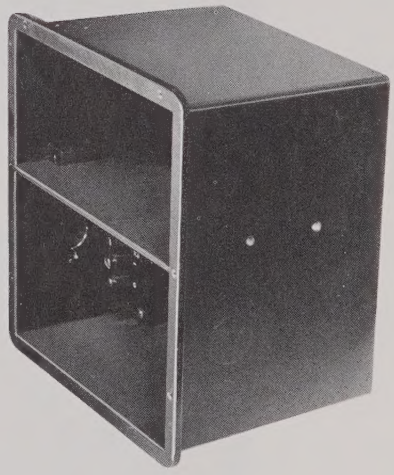
Upper Front Cover



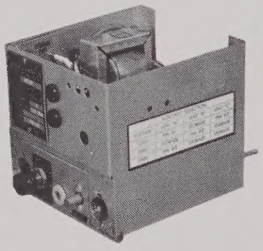
Control Set Point Knob

Indicating Meter

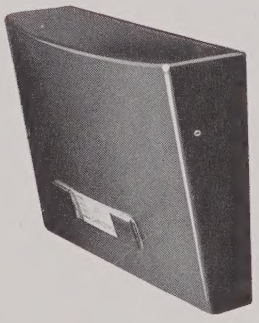


Compartmented Housing



Control Chassis



Lower Front Cover

MODEL 477P

MAJOR COMPONENTS



F-12665

# SPECIFICATIONS

## Meter

| | |
|---|---|
| Scale Length | 6 inches |
| Minimum Span | 9 mv or 0-300°F - Type J |
| Calibrated Accuracy | ± 1/2% of full scale |
| Sensitivity | 50 microamps for full scale deflection (nominal) |
| Internal Resistance | 20 ohms per millivolt (nominal) |
| External Resistance | a) As standard, calibrated for 15 ohms and supplied with replaceable compensator to make up difference between calibrated resistance and actual value of external resistance. May be calibrated for other values of external resistance if required.<br>b) Units with bridge type TCB are adjustable for external resistances up to 20 ohms |
| Compensation | a) Automatic cold junction temperature compensation -- mechanical standard; electrical optional. Range 40 to 130°F<br>b) Copper coefficient compensation. Range 40 to 130°F |
| Thermocouple Break Protection | Standard type TCB furnished unless otherwise specified. Bridge type TCB available |

## Chassis

| | |
|---|---|
| Control Output | Direct current |
| Control Output Span | 2 to 12 milliamperes into 1500 ohm load |
| Proportional Band | Adjustable from 0.5% to 5% of full scale |
| Control Adjustment | External control set point knob adjustable over 100% of scale. Reset control internally adjustable |
| Power Requirements | 9 volt amperes |
| Power Supply | Interchangeable: 120, 208, 240 volts a-c, 50 - 60 cycle |

## Dimensions and Weights

| | |
|---|---|
| Overall Dimensions | 9 15/16" high x 9 5/8" deep x 9" wide |
| Cutout for Flush Mounting | 8 1/4" wide x 9 1/4" deep<br>NOTE: Meter housing will extend approximately 6" into panel when flush mounted |
| Net Weight | Approximately 16 pounds |
| Shipping Weight | Approximately 23 pounds |

## MATERIAL WARRANTY

All equipment except tubes, photocells, and thermocouples, which within one year from date of shipment is found to have been originally defective, will be repaired (replaced if necessary) free of charge if returned prepaid to the Factory at Rockford, Illinois.

# DESCRIPTION

## General Description

The Model 477P Capacitrol is a millivoltmeter-type indicating controller with a d-c current output for proportional control of an intermediate or final control device. It is used as the primary control instrument for driving magnetic amplifier/reactor systems or silicon controlled rectifier power controllers for the proportional control of load power.

## Control Specifications

The Model 477P Controller has a proportional direct current output of 2 to 12 milliamperes and is designed to be used with a 1500 ohm load. Two adjustments, "Reset" and "Proportional Band", are adjustable from the front of the instrument. Their operation is described under "Control Adjustments". The proportional band is adjustable from 0.5% to 5% of full scale. Proportional control action occurs when the meter indicator is within the proportional band range of the instrument, with its position on the scale determined by the red control set pointer. After the controlled load has become thermally stable, any offset between the meter indicator and the red control set pointer can be corrected with the reset adjustment as described under "Control Adjustments".

The control point can be easily adjusted through the full length of the instrument scale by means of a knob located just below the scale. The red signal light indicates when power is applied to the chassis. The output is from terminals 1 and 4, with terminal 4 of negative polarity and terminal 1 positive.

## Description of Electronic Circuit

The Model 477P incorporates a transistorized oscillator and d-c amplifier, with the d-c output of the amplifier controlling an external power controller which, in turn, controls the load power. At a position on the scale below control point, the collector current of the oscillator transistor is of sufficient magnitude so the output of the d-c amplifier is greater than 12 milliamperes. As the indicator approaches control set point, a small vane or flag suspended from the indicating pointer passes between two flat coils mounted on the control set point arm. As the flag moves upscale between the coils,

the collector current of the oscillator transistor is reduced. With the flag fully between the coils, the collector current is decreased to a minimum so that the output of the d-c amplifier is less than 2 milliamperes. Proportional control action occurs when the flag traverses a fixed distance between the coils, as discussed under "Proportional Control". In the 477P the input to the d-c amplifier is proportional to the oscillator collector current, controlling the amplifier output. The proportional band is made larger or smaller by adjusting the level of feedback from the d-c amplifier to the oscillator, which regulates the oscillator collector current change with respect to flag movement. When there is no feedback the proportional band is at minimum, or 0.5% of full scale, and at maximum feedback the proportional band is increased to 5.0% of full scale or greater.

Proportional Control

Proportional control action provides a continuous linear relation between the value of the measured variable and the position of the final control element. Overshoot and undershoot is minimized, and close tolerance control is maintained. As stated above, proportional control of the d-c output current occurs when the flag is between the coils, and its position in the coils automatically determines the output of the instrument in d-c milliamperes to an external power controller. The external power controller (or magnetic amplifier) is generally set up so that a 12 milliampere input from the 477P will result in maximum power applied to the load, and a 2 milliampere input will produce a minimum (or zero) power to the load. A means of controlling load power is therefore obtained. After the meter indicator has reached the proportional band (with the flag between the coils) and moves upscale toward the control set point, the instrument's output in d-c milliampere decreases. At control set point the output would be approximately 7 milliamperes.

Figure 1 is an example showing the instrument's proportional band (PB) curves for a 5% setting and a 0.5% setting. The 5% PB setting is obtained by turning the PB adjustment fully clockwise. Also, in Figure 1 are the 620 Series and Model 610A power transfer curves. The power transfer curves also assume that the input control winding resistance of the 610A and 620 Series is 1500 ohms. The curves give a relative indication of power output. For example, if a voltmeter was attached to the test jacks and the meter read 12 volts (8 ma with 1500 ohm load), the 620 Series power output would be 60% of maximum output power. If a Model 610A was used the output of the 610A would be about 42.5 volts d-c, which would be the input to a reactor used in conjunction with the 610A magnetic amplifier.

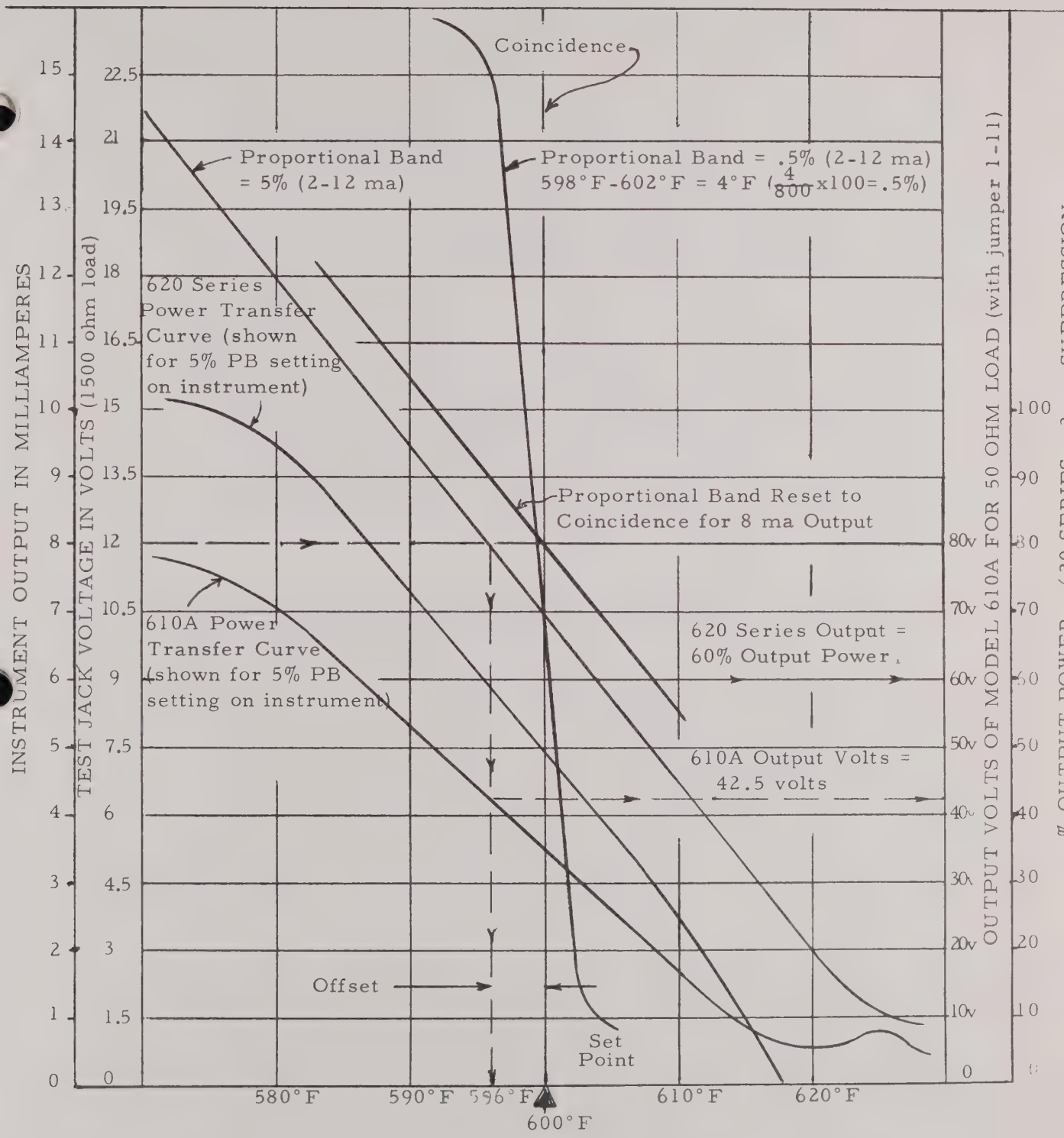

Coincidence
Proportional Band = 5% (2-12 ma)
Proportional Band = .5% (2-12 ma)
598°F-602°F = 4°F ($\frac{4}{800}$x100=.5%)
620 Series Power Transfer Curve (shown for 5% PB setting on instrument)
Proportional Band Reset to Coincidence for 8 ma Output
610A Power Transfer Curve (shown for 5% PB setting on instrument)
620 Series Output = 60% Output Power
610A Output Volts = 42.5 volts
Offset
Set Point
INSTRUMENT OUTPUT IN MILLIAMPERES
TEST JACK VOLTAGE IN VOLTS (1500 ohm load)
OUTPUT VOLTS OF MODEL 610A FOR 50 OHM LOAD (with jumper 1-11)
580°F
590°F
596°F
600°F
610°F
620°F

Figure 1

Example of Proportional Control Action
as the Meter Indicator Moves Upscale
Through the Proportional Band of a 0-800°F Meter

As shown in the example, the meter would indicate about 596°F which would mean an offset of 4°F from control set point. This offset is corrected using the reset adjustment as described under "Control Adjustments". The example shows the proper reset adjustments for the particular control point selected. In this example, the power transfer curves would also be shifted over the same amount as the proportional band curve.

In using the 477P in control systems, the proportional control of load power is obtained by using the direct current output of the 477P to control a magnetic amplifier (Model 610A) reactor combination or a Series 620 "SCR" power controller. The external wiring diagrams, pages 7 through 11, show typical connections. If reactors are used to control load power, a shunting resistor should be connected directly across the reactor control winding terminals, as shown in the wiring diagrams, to protect the reactor control winding in case the control circuit is opened under load, inducing a high voltage in the control winding.

As can be seen in Figure 1, there is always a small output when using a 610A or magnetic amplifier to drive a reactor. This results in a small amount of power always being applied to the load, even when the instrument's output is less than 2 milliamperes. Two power amplifiers are available to control reactors: the Model 610A - a magnetic amplifier, and the Model 630A - an SCR type controller with a d-c output. The specifications are as follows:

| | |
|---|---|
| Model 610A | Excitation 120 v, 60 cycle; output - 5-75 v d-c, maximum power output to reactor control windings - 188 va. Used with reactors up to 30 kva rating. |
| Model 630A | Excitation 120 v, 60 cycle; output - 0-80 v d-c, maximum power output to reactor control windings - 750 va. Used with reactors up to 130 kva rating. |

## Unpacking the Instrument

This precision instrument and its associated equipment have been carefully manufactured and packed at the factory. Remove the instrument and accessories from the packing box and check items against the packing slip. If the equipment is found to be damaged in transit, report damages to the carrier immediately. Repack in original packing box until ready for installation.

CAUTION:

Handle with care.
Safeguard instrument from shock before and after installation.
Avoid oil accumulation and exposure to moisture.
Keep instrument temperature under 130°F and over 40°F.

## Mounting Instructions

Locate instrument to avoid excessive vibration, shock and temperatures outside the range of 40°F to 130°F. Avoid furnace walls, radiation of heat, machine frames and outside walls. Provide suitable shelter against moisture and temperature extremes if installed outdoors. Refer to appropriate drawing for mounting details.

## Power Wiring

The instrument is wired for 240 volts a-c. If available power supply is other than this, the proper voltage can be selected as follows:

The lower front cover should be removed by loosening the two screws. The chassis assembly can then be removed by firmly pulling forward. A voltage selection board is located on the top left side of the chassis. The voltage can easily be changed by plugging the wires onto the proper pins as shown on the right side of the chassis enclosure and as illustrated in Figure 2.

The two marked pins #1 and #2 are used for the voltage range desired while the other pins are used for storing the unused wires. The wires are marked A, B and C. The connections are as shown below:

VOLTAGE SELECTION

| Voltage | Lead "A" | Lead "B" | Lead "C" |
|---|---|---|---|
| 120 v | Pin #1 | Storage | Pin #2 |
| 208 v | Storage | Pin #2 | Storage |
| 240 v | Pin #2 | Storage | Storage |

Figure 2

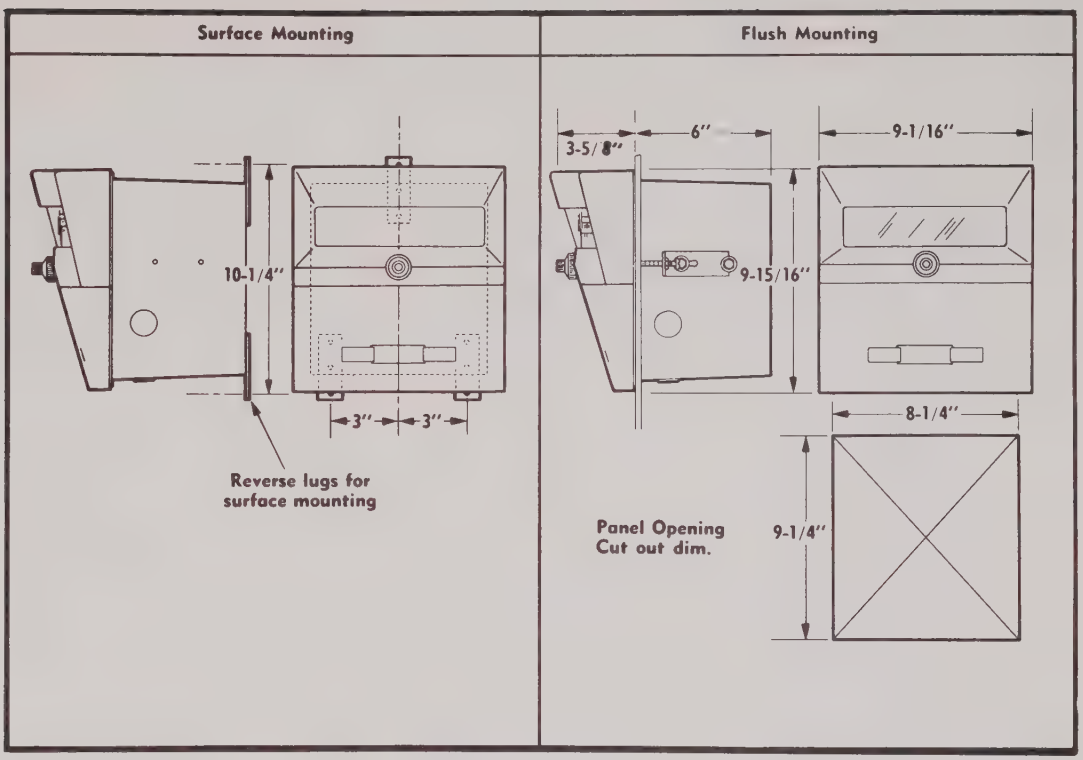



Figure 3
Mounting Dimensions
(Rigid Mounting)

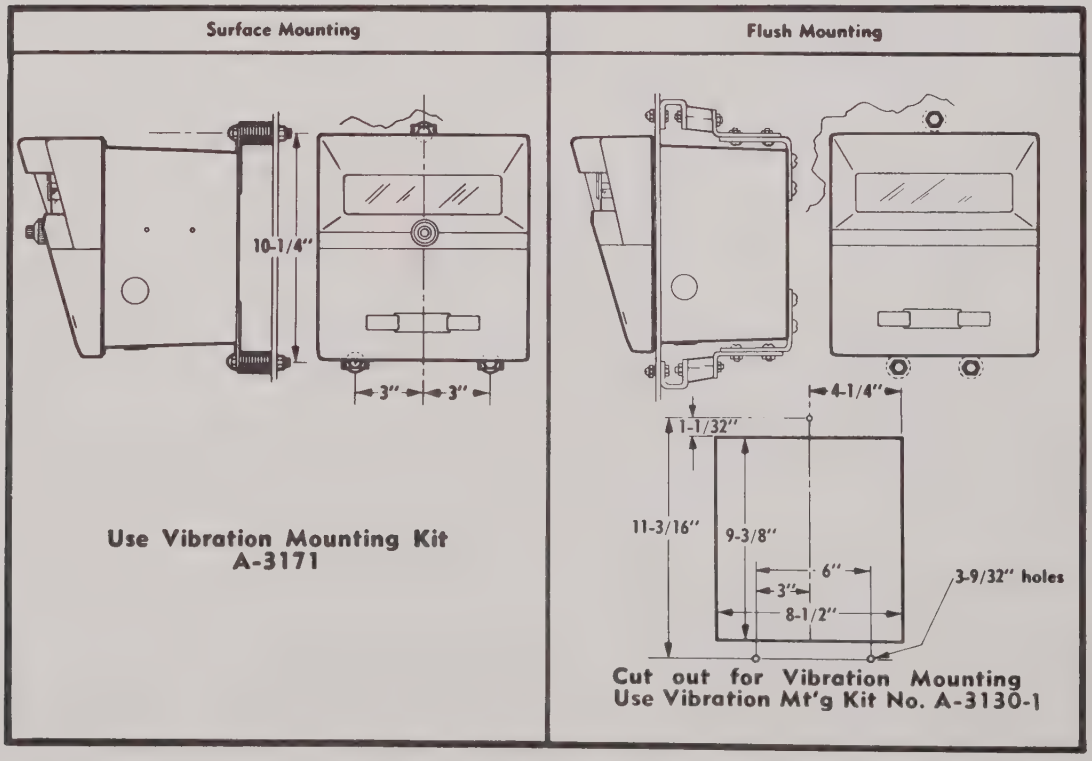



Figure 4
Mounting Dimensions
(Vibration Mounting)

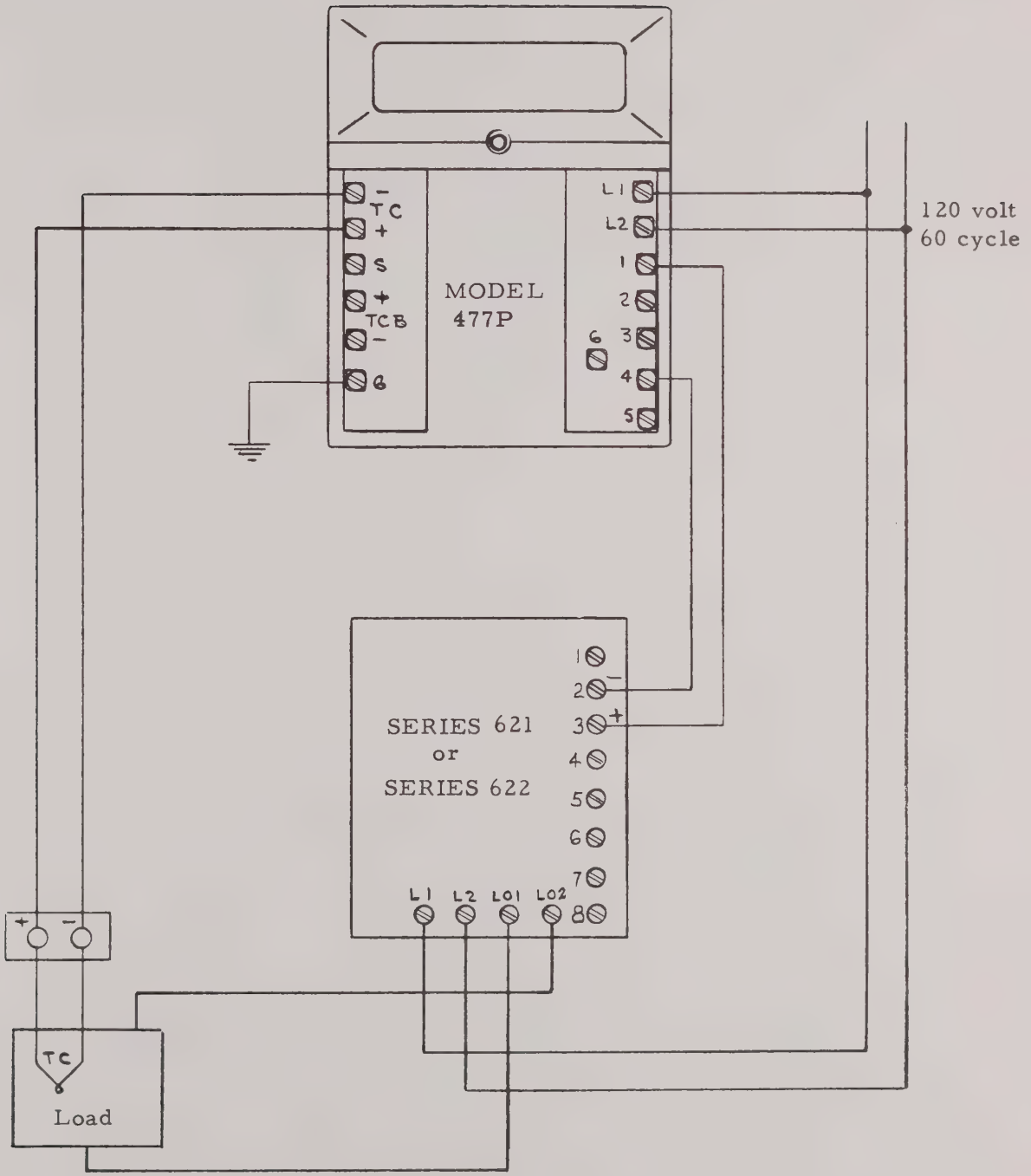
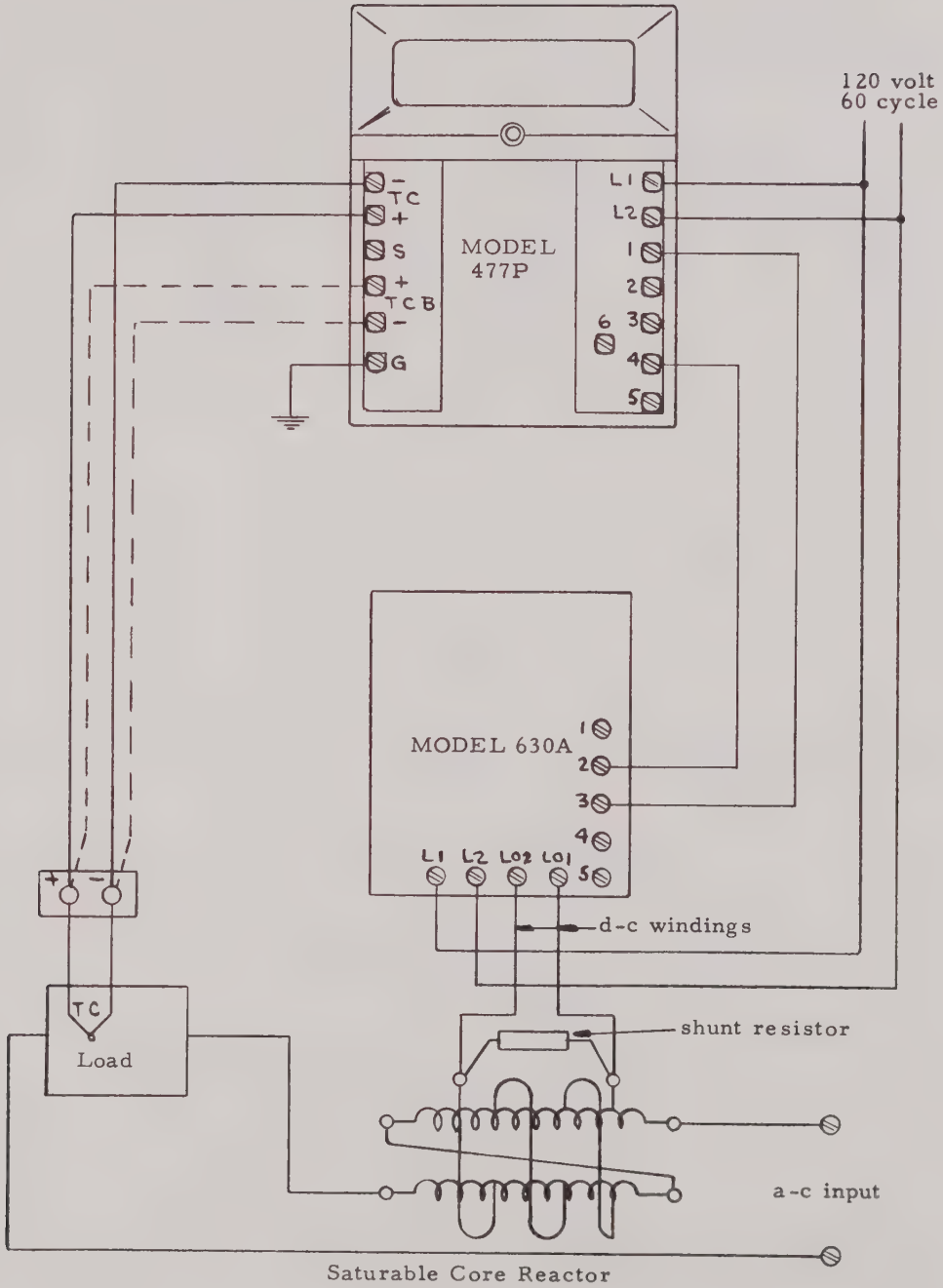



Figure 5

External Wiring Diagram of Model 477P Driving a Series 621 or 622 Power Controller




1. Reactor coils may be parallel connected for lower line voltage. Refer to manufacturer's specifications.
2. Identification of control winding terminals differ with various manufacturers.

Figure 6

External Wiring Diagram of Model 477P Driving a Saturable Core Reactor Through a Model 630A SCR Pilot Amplifier

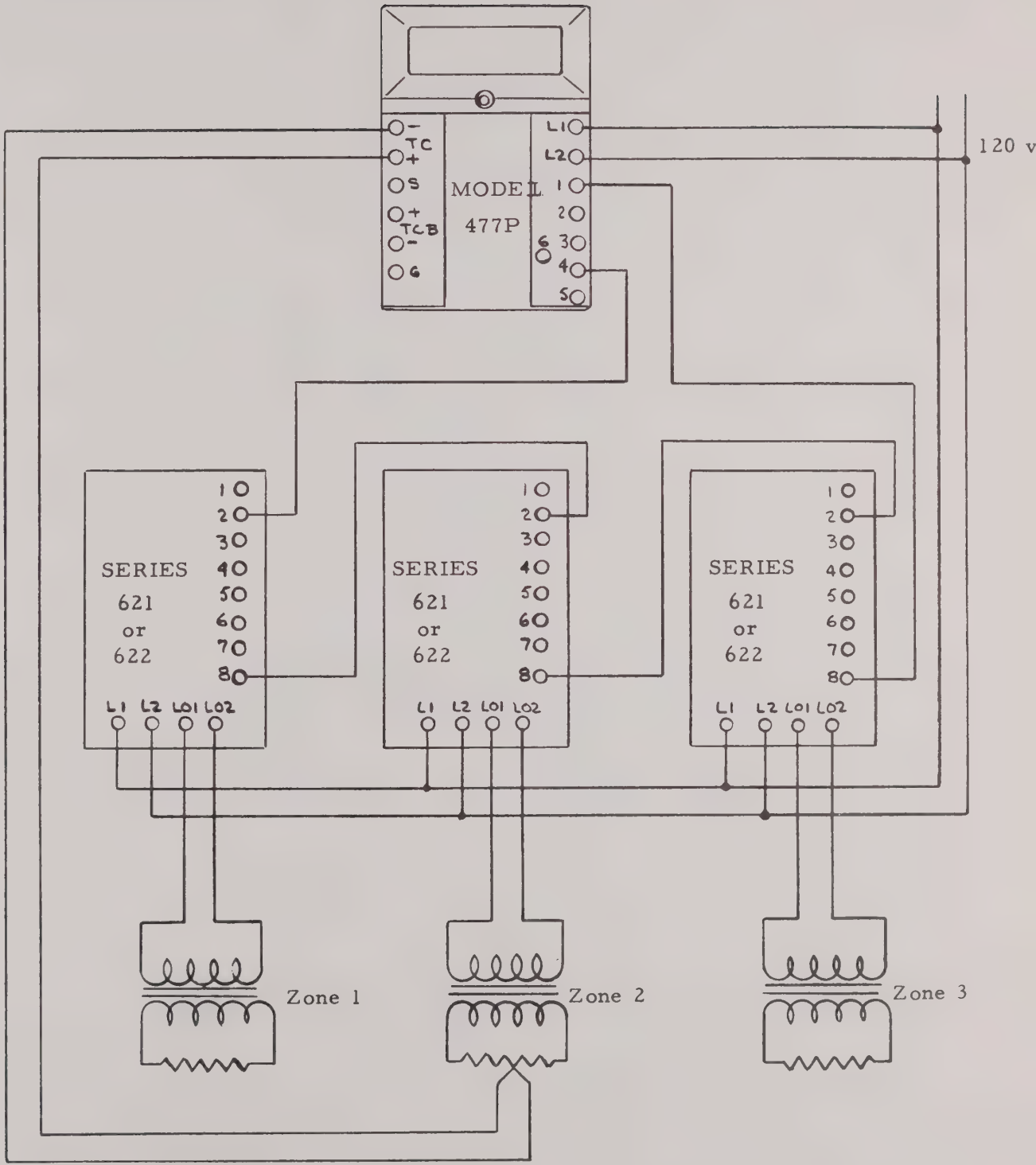



Figure 7

External Wiring Diagram of Model 477P Controlling Three Zones from a Central Zone using Series 621 or 622 Power Controllers

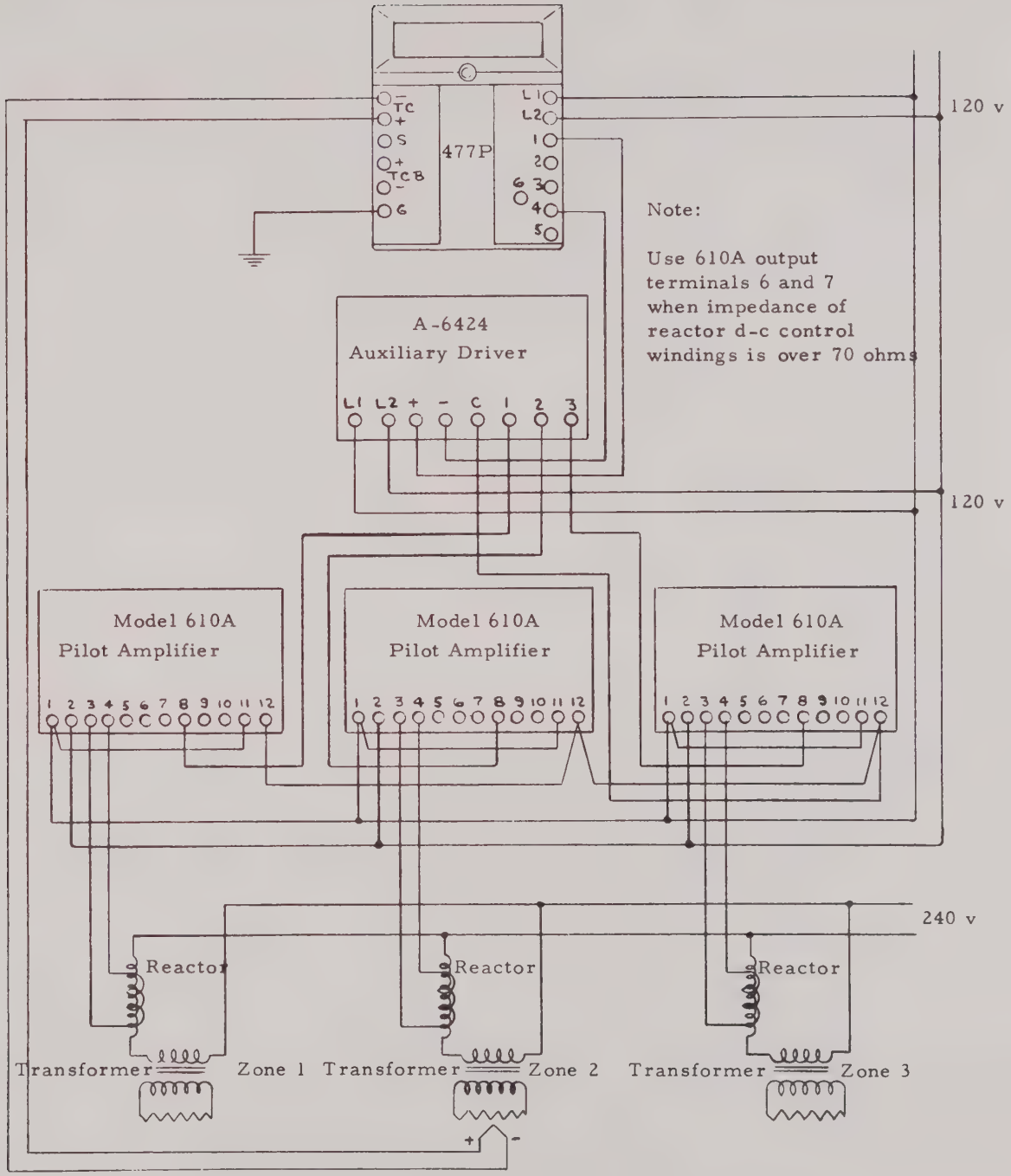
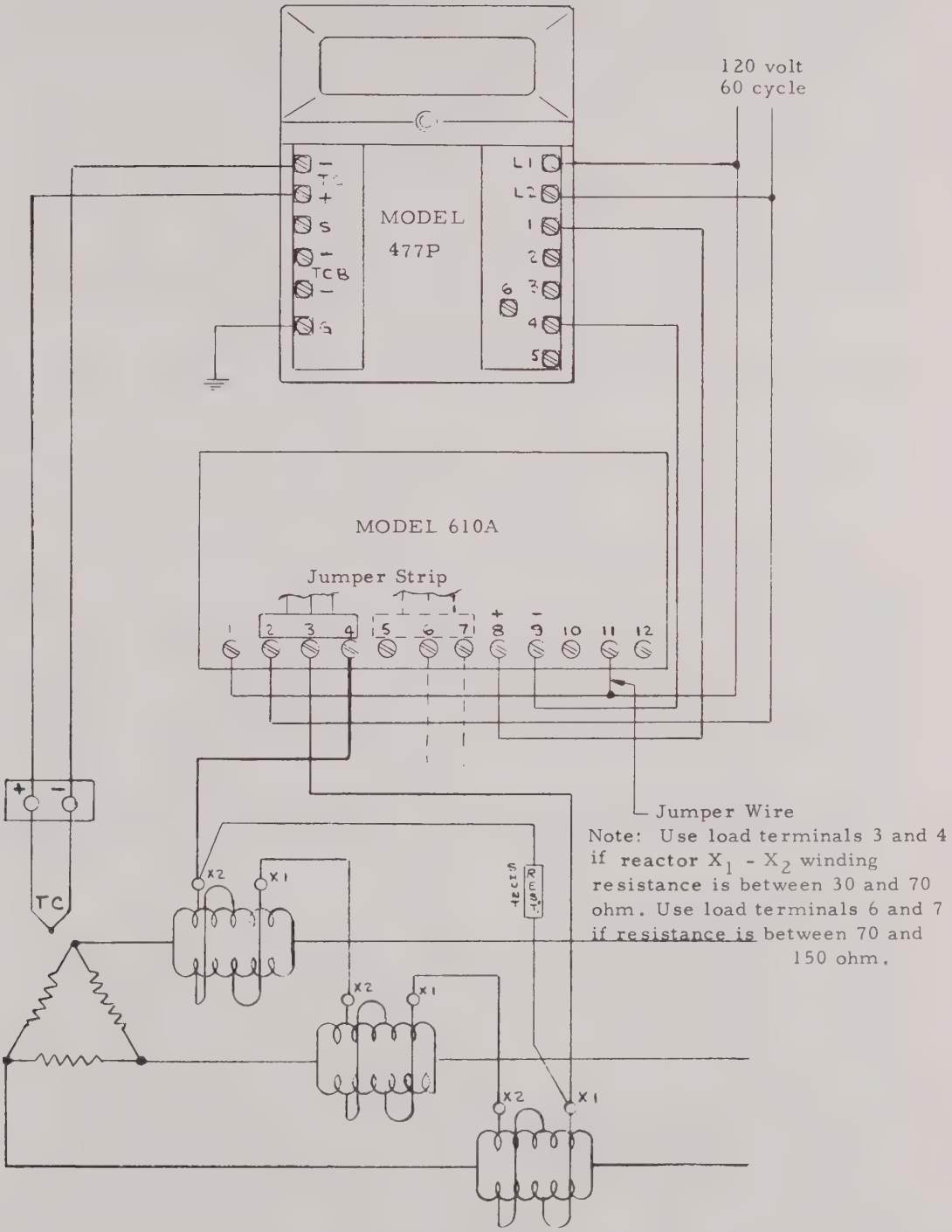



Figure 9

External Wiring Diagram of Model 477P Controlling Three Zones from a Central Zone using Saturable Reactors and Model 610A Pilot Amplifiers (note that an auxiliary driver is used for impedance matching)




Note: Three phase reactors may be individually shunted.
Reactor d-c coils may be parallel connected in special cases.
Refer to manufacturer's specification sheets accompanying reactor.

Figure 9

External Wiring Diagram of Model 477P Driving a Three-Phase Saturable Reactor Through a Model 610A Pilot Amplfier

After the proper voltage has been selected and the chassis replaced the instrument is then ready for wiring. The instrument will operate on both 50 and 60 cycle a-c systems. The desired a-c supply voltage is connected to terminals L1 and L2 inside the lower compartment. If the instrument is equipped for back wiring, remove the back panel to expose the terminal strips. All wiring should be in accordance with the applicable electrical codes. Where maximum protection of the instrument is desired a 1/8 ampere slow blow fuse may be added in the power line to the instrument.

Solid wire is recommended for instrument wiring. If stranded wire is used, tin the ends to provide secure connections.

The instrument should be grounded. This is accomplished by attaching the ground terminal (G) directly to a good ground, such as a cold water pipe.

CAUTION: Do not connect the ground terminal to the neutral a-c line.

Meter Shunt Wire

After the instrument is installed, disconnect the jumper wire across terminals marked "Shunt", "TC-" and "TC+". This wire is used to shunt or dampen the meter movement for protection during shipping, handling and installing the instrument, but should be removed for normal operation. Replace the shunt wire when handling or reshipping the instrument and position the red control set pointer fully upscale.

If the meter assembly is removed from the case, an automatic shunt device protects the meter assembly from damage. Other shunt wiring is not required.

Thermocouple Wiring

Do not run thermocouple leadwire with other power or control wiring. However, several thermocouple leadwires may be run in the same conduit if desired.

Use only extension leadwire correct for the type of thermocouple (TC) as specified on the scale. Except for certain radiation detectors, ordinary copper wire cannot be used. The types of sensing elements most commonly specified are:

| | |
|---|---|
| Iron-Constantan | Type J |
| Chromel-Alumel | Type K |
| Platinum-Platinum 10% Rhodium | Type S |
| Platinum-Platinum 13% Rhodium | Type R |
| Heat-Eye Radiation Pyrometer | - - - |

See Barber-Colman Thermocouple Catalog for a full selection of thermocouple assemblies and extension leadwire.

Proper polarity (+) and (-) of the leadwire must be observed to obtain correct readings. The negative wire is usually coded red. Correct polarity of the leadwire can be checked by forming a temporary junction at the far end, heating this junction with a match, and noting the deflection of the meter indicator. An upscale deflection is proof of correct polarity of the leadwire.

The thermocouple should then be connected to the leadwire and the indicating pointer should again deflect upscale when the thermocouple hot junction is heated. If the indicator moves downscale, reverse only the thermocouple connections at the terminal block since the leadwire has already been correctly connected to the instrument.

Secure the leadwires firmly under the terminal screws. If desired, spade lugs may be used.

Thermocouple Break Protection (TCB)

Each instrument is equipped with thermocouple break protection (TCB). If a break in the thermocouple circuit occurs, the meter indicator will be driven upscale past the control set point, causing the power to the controlled load or process to be turned off and guarding against overheating when an open thermocouple circuit occurs.

Two systems of thermocouple break protection are used. Standard models of the instrument are provided with a small d-c voltage wired into the thermocouple circuit to drive the movement upscale in the event of an open circuit. If so specified, bridge type TCB is furnished. With the thermocouple forming one leg of the bridge circuit, a break in the thermocouple or leadwire produces an unbalance causing the indicator to be driven upscale to shut off control power.

Note: Check to see that jumper wire on underside of chassis is attached to pin ST for models equipped with standard type TCB or to pin BR if bridge type TCB. Models are shipped as ordered, but because of interchangeability of chassis this should be verified.

| | |
|---|---|
| Standard Type TCB | Although instruments equipped with standard TCB can be operated without TCB connected, its use may be desirable on some applications to guard against overheating in the event of an open thermocouple<br><br>The preferred method of connecting TCB is shown in Figure 10. Use extension leadwire as required to make the connections between the instrument TC terminals and the thermocouple head. Use copper wire to connect |

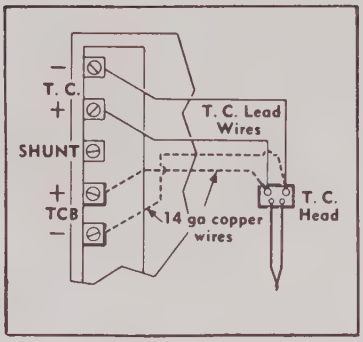



Figure 10

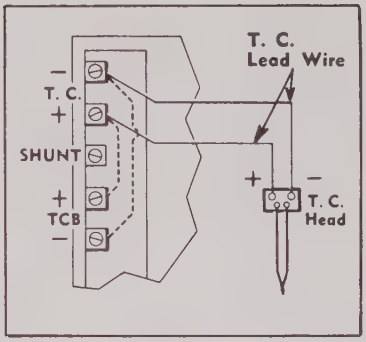



Figure 11

the TCB terminals to the thermocouple head, observing polarity. Wiring for TCB may be run in the same conduit with thermocouple leadwire. After connections are made, check for any error of indicator reading that may have resulted.

Although not recommended, an optional method of connecting TCB is to use jumpers at the instrument terminals as shown in Figure 11. As the length of leadwire used affects the amount of TCB compensation required, it is suggested that this method be used only with short leadwire lengths, 10 feet or less, and that the amount of TCB error be checked.

Standard Type TCB (continued)

To check for TCB operation, disconnect the thermocouple to simulate a broken thermocouple but leave the TCB wires connected to the leadwire. When the instrument is powered, the indicator should move upscale above the red control set pointer to a position beyond the proportional band for zero output. No power would then be applied to the load. To check for TCB error, reconnect the thermocouple, power the instrument and read the temperature with the hot junction of the thermocouple held at a steady temperature. Then disconnect the wires at the TCB terminals, and note if the indicated temperature decreases. Reconnect to see if indicated temperature increases. If a shift in reading is noticed, adjust the screw on top of the plastic cover so that the reading with TCB connected is at the same point as read with TCB disconnected. If an adjustment is made, the ambient reading will also be shifted downscale.

Note: Adjustment should be made for correct ambient temperature reading before this check is made. See section on "Cold Junction Compensation".

If the instrument is equipped with bridge type thermocouple break protection, the need for any external TCB wiring is eliminated. See Figure 12.

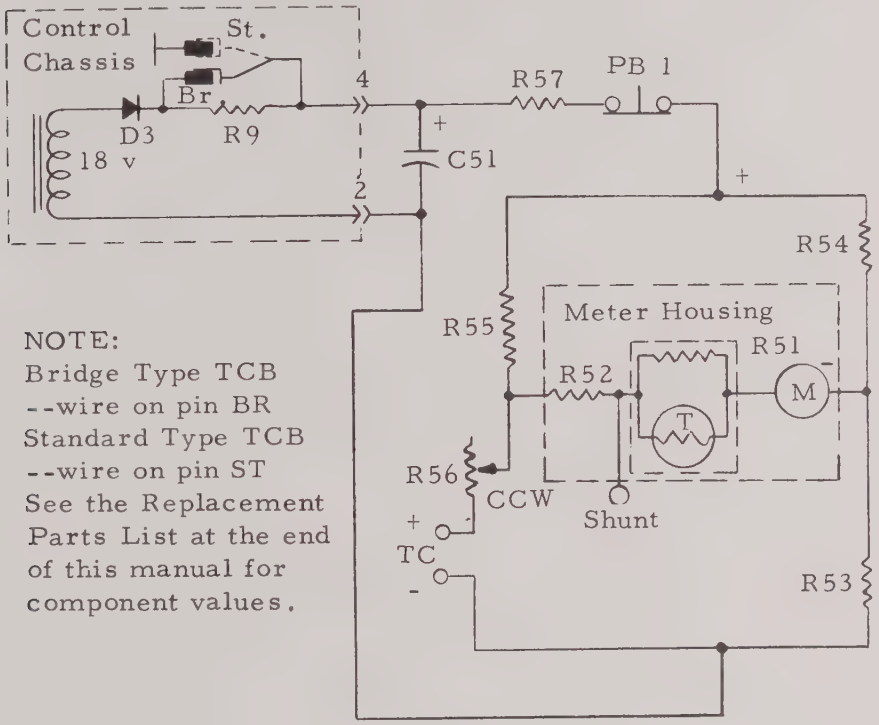



Figure 12

Bridge Type TCB

Bridge type TCB, when properly adjusted, eliminates the error that occurs with other types of TCB circuits. It also compensates for the thermocouple and leadwire resistance, as discussed in the section below. Adjustment is made in the following manner:

Remove the lower front cover, revealing the left-hand terminal strip and the push button over the words "TCB ADJ" with the adjustable potentiometer underneath. With the thermocouple connected and maintained at a steady or fixed temperature, and with the instrument powered, depress the push button and note the meter indicator reading. Then release the push button again and note the indicator reading. If there is a difference between the two readings, adjust the potentiometer with a screwdriver, with the push button released, until the meter indicator reading is the same as the initial reading when the push button was depressed. The proper adjustment is obtained when there is no discernable difference in meter readings with the push button depressed or released.

| | |
|---|---|
| Bridge Type TCB (cont'd) | To check for TCB operation, disconnect one of the thermocouple wires to simulate a broken thermocouple. With the instrument powered, TCB is functioning properly if the meter indicator is driven upscale above the red control set pointer causing the power to the load to be turned off. |

TCB, either standard or bridge type, cannot be used with radiation detectors or the Series 350 Reference Voltage Source. An instrument with standard TCB requires only that TCB connections not be made. If instrument was purchased equipped with bridge type TCB, and it is later desired to convert for these applications, please consult your Barber-Colman field office.

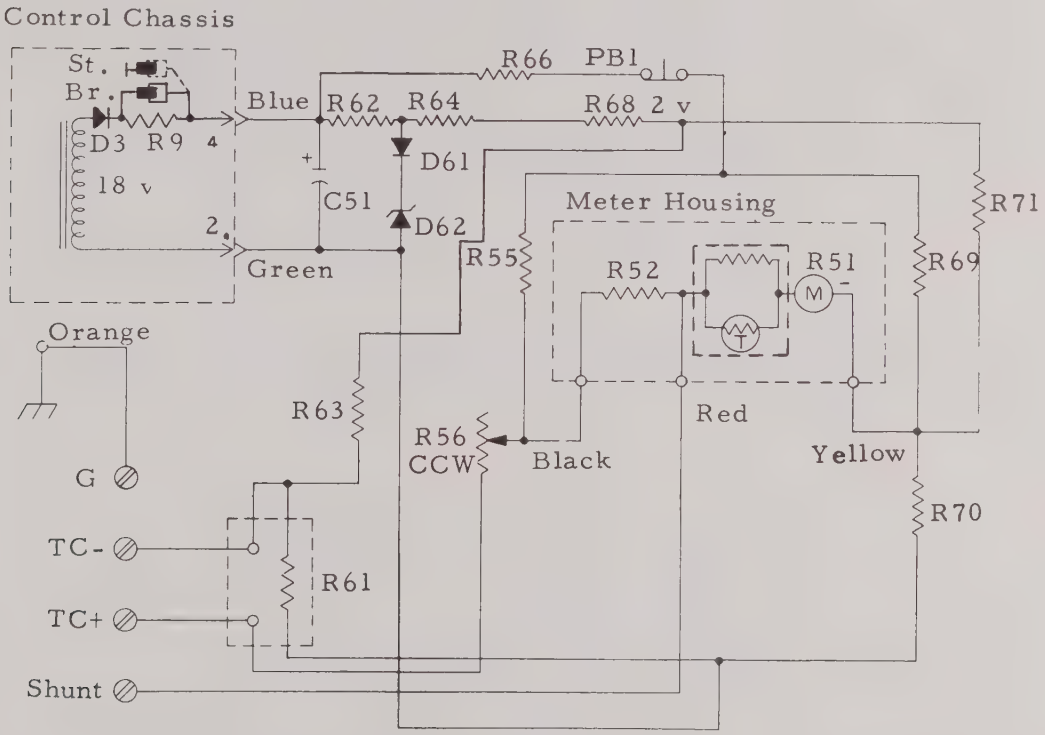
## Thermocouple and Leadwire Resistance Compensation

| | |
|---|---|
| Standard Type TCB | The external resistance, for which the meter has been calibrated and as marked on the scale, is the combined resistance of the leadwire and thermocouple. Meters equipped for standard thermocouple break protection are usually calibrated for 15 ohms (Ext.Res.15 ohms) which is greater than the combined resistance of most thermocouples plus leadwire used. The balance of the resistance, 15 ohms minus the actual external resistance, is inserted on a removable resistance strip located just under the meter section. The resistance value is marked on the strip and is inserted at the time of the original order. Other values are available. |
| Bridge Type TCB | Instruments equipped with the bridge type TCB circuit are normally calibrated for 25 ohms which allows up to 20 ohms for the external thermocouple and leadwire resistance. An adjustable potentiometer (R4), located on the left terminal strip inside the lower compartment, is used to compensate for the difference in resistance between the allowable 20 ohms and the actual thermocouple plus leadwire resistance. The proper adjustment of this potentiometer also eliminates any TCB error. See page 15 for adjustment procedure. |

## Cold Junction Compensation

For measuring temperature, thermocouples are the most commonly used sensing devices. They produce a voltage when there is a temperature difference between the "hot" or measuring junction and the "cold" junction located in the meter assembly. Since the difference in temperature between the hot and cold junctions determines the amount of millivoltage produced, it is necessary to keep the cold junction temperature constant, or to compensate for any changes that occur at this point. Compensation for temperature changes at the cold junction is accomplished either

mechanically or electrically, depending on model variation. Mechanical cold junction compensation, employing a bi-metallic strip, is furnished as standard on non-suppressed range instruments unless otherwise specified. Electrical cold junction compensation is usually provided with suppressed range instruments and can be supplied with any instruments that have bridge type TCB. See Figure 13.




See the Replacement Parts List at the end of this manual for component values.

Figure 13

Notes:

1. Electrical cold junction compensation is accomplished by utilizing the resistance change, due to temperature, of resistor R1. Value depends on type of thermocouple used.

2. With electrical cold junction and suppression, value of R10 depends on the type of thermocouple and the amount of suppression desired.

**Standard or Bridge TCB with Mechanical Cold Junction**

After the instrument has been mounted, the cold junction reading of the meter should be checked. If the instrument is standard (i.e., with mechanical compensation), the cold junction check is made in the following manner:

Disconnect power leads and TC leadwire at the instrument. The indicator should come to rest at the ambient temperature of the meter; it is not supposed to read zero. Place a thermometer at the TC instrument terminals to read ambient temperature.

If the pointer does not indicate the ambient temperature, slowly adjust the screw located on top of the meter cover until it does. Because cold junction compensation is automatic, further corrections for changes in the ambient temperature need not be made.

**Bridge TCB with Electrical Cold Junction**

If the instrument has a non-suppressed range but is equipped with the electrical cold junction feature and bridge type TCB, check for proper cold junction adjustment according to the following:

The meter indicator should read zero when the instrument is unpowered. If the meter is not at zero, adjust the screw located on top of the meter cover until zero is obtained. Connect a jumper wire between TC- and TC+ and with the instrument powered, adjust the TCB potentiometer so no indicator movement occurs when the TCB push button is depressed and released. Place a thermometer at the TC instrument terminals to measure the ambient temperature reading. With the instrument still powered, the meter indicator reading should be the same as the ambient temperature reading. Further adjustments are not required because of the automatic electrical cold junction compensation.

For instruments with a suppressed range using electrical cold junction compensation:

The meter indicator should come to rest at the lowest temperature reading on the scale when the instrument is unpowered. If it does not, slowly adjust the screw located on top of the meter cover until it does. The meter is then properly adjusted and needs no further adjustment because of automatic electrical cold junction compensation.

## Control Action

The red control set pointer is adjustable by use of the knob located just below the indicating scale. The black indicating pointer will move to indicate the temperature at the thermocouple. The Model 477P has an instantaneous response because solid state devices operate without warm-up time. When the red signal light glows, the instrument is powered and the light will remain on until the power is turned off to the instrument. If a d-c voltmeter is connected across the test jacks, assuming the output of the instrument is connected to a controller, the voltmeter output will decrease when the meter indicator approaches the control set pointer and the region where proportional control occurs.

## Control Adjustments

Final control action adjustments should be made after the unit has been in operation 45 minutes and has obtained maximum stability. The controls are accessible by removing the lower front cover which is easily removed by first loosening the two screws.

Proportional Band Adjustment:

The proportional band (PB) adjustment is used to vary the proportional band from 0.5% to 5% of full scale. Turning the PB adjustment clockwise will increase the PB, and counterclockwise will decrease it. The ideal PB setting is at its furthest counterclockwise or minimum adjustment which will permit straight line control. This setting is best obtained in the following manner:

1. Set the PB adjustment fully clockwise (maximum PB) and apply power to the controlled load.

2. When the controlled load temperature has become thermally stable at or near control set point, reduce the PB by turning the adjustment counterclockwise one graduation on the dial. To simulate a control upset, also move the control set point a few divisions. Allow time for the process to reach the new control point setting and then observe if there is a cyclic variation. This would appear as an up and down-scale movement of the indicator pointer.

3. If cycling is not present, repeat Step 2 until cycling occurs.

4. From the setting where cycling is continuous, increase the PB by turning clockwise one graduation. Again change control set point and allow time for load temperature to stabilize. At this point, cycling should have disappeared and straight line control established.

With proportional band properly set, response time of the instrument (sensitivity to load changes) is optimized, and the control offset is also reduced.

Reset:

A "reset" adjustment (the slotted shaft) is located on the left front of the control chassis, accessible by removing the lower compartment cover.

Reset adjustment provides a means of aligning the meter indicator with the control set pointer to correct for offset. If the meter indicator does not coincide with the control set pointer after the controlled load has become thermally stable, an alignment adjustment should be made. Use a small screwdriver to reposition the reset adjustment capacitor. Turning the reset adjustment counterclockwise will decrease the output of the instrument, thereby shifting the meter downscale so as to produce a lower temperature. Conversely, turning the reset adjustment clockwise will result in shifting the meter indicator upscale, producing a greater temperature. The reset adjustment should be in small increments with sufficient time allowed after each adjustment to permit the controlled load to again become thermally stable. The proper reset adjustment occurs when the meter indicator coincides with the control set pointer when the load is thermally stable.

## Routine Servicing

Servicing of the instrument, in the usual sense, is not required. It is recommended, however, to make routine checks of the condition of the thermocouple, extension wire and power connections. Meter accuracy may be verified from time to time. The frequency of these checks may vary from one month to three months, depending on the extent of usage, accuracy required and the seriousness of any problems that may be created due to possible "down time".

Spare parts for emergency servicing should be kept on hand. Where a number of instruments are located together, the plug-in parts are interchangeable to allow minimum inventory.

When trouble is encountered, the serviceman should familiarize himself with the process and instrument application to determine the exact function of the instrument as applied. The instrument trouble usually can be traced to two basic problems: measurement or control.

## Measurement or Control Trouble

Measurement trouble can be detected by observing the pointer position. If the measured temperature is known to be in error, check the following:

1. Open or broken thermocouple, leadwire or connector. Check visually or with a volt-ohmmeter.

2. Deteriorated thermocouple. Compare reading with a test thermocouple or check output with a Barber-Colman portable potentiometer.

3. Ascertain that the instrument is grounded.

4. Accidental shorts, grounds or moisture in the leadwire (especially with asbestos type insulation).

5. High resistance in leads due to loose connectors, poor splicing, dirty switch contacts, and other faulty connectors.

6. Problems caused by vibration or shock.

7. Meter accuracy. This can be checked with a Model 330P portable potentiometer.

8. Errors due to oil and grease. Do not oil or grease any part of the instrument.

9. Incorrect cold junction (ambient) setting. The correctness of this setting should be checked following any other meter servicing.

10. Incorrect TCB adjustment (see section on "Thermocouple Break Protection").

Control trouble may be detected by observing control point and indicator pointer position. If control action does not occur at control point, do the following:

1. Check electrical connectors and correctness of line voltage. Ascertain if trouble is internal or external to the instrument.

2. Determine if instrument and associated equipment are powered; check load power for open circuits in three-phase circuits.

3. Check supply voltage to the components. It should be within ± 10% of rated line voltage. Excessive line voltage variations can cause large fluctuations in load power.

4. Check to see if the reactor rating is compatible with the load rating.

5. Check the output of the Model 477P by connecting a d-c voltmeter to the test terminals. When the indicator is well to the left of the control set point, the meter reading should be greater than 18 volts d-c. When the indicator is well to the right of the set point, test meter should read 3 volts d-c or less.

6. If the instrument output is low (less than 18 volts d-c) when the indicator is considerably to the left of the set point, check for improper reset adjustment.

7. If there is no power applied to the load with the instrument energized, attach a d-c voltmeter to the test jacks. If the voltmeter indicates zero output, make sure the meter indicator is well to the left of the set point and then turn the reset adjustment through its entire adjusting range. If the d-c voltmeter then indicates an output to the controller, let the controlled load stabilize and then make an adjustment of reset as described under "Control Adjustments". If the instrument does not then function, further servicing or replacement of the control chassis is suggested.

## Calibration Check

The instrument has been calibrated at the Factory to the specified limits of accuracy. No further adjustment need be made. If, however, it is later decided to check the calibration, obtain a Barber-Colman Model 330P Portable Potentiometer, or its equivalent, and perform the following:

| | |
|---|---|
| Standard TCB Mechanical Cold Junction | If instrument is equipped with standard TCB and mechanical cold junction compensation:<br><br>Follow directions outlined in the Model 330P Instruction Manual on page 11. |

**Bridge TCB with Mechanical or Electrical Cold Junction**

If instrument is equipped with bridge type TCB:

Remove the TC wire and short out the TC terminals by connecting a jumper wire between terminals marked TC- and TC+. Then, with the instrument powered, adjust the TCB potentiometer so no meter indicator movement occurs when the TCB push button is depressed and released. With the jumper wire then removed, and the instrument unpowered, connect a Barber-Colman 330P (or equivalent) to the thermocouple terminals and follow instructions stated below.

**Bridge TCB with Mechanical Cold Junction**

If instrument has mechanical cold junction compensation:

Procedure for calibrating is as outlined in the Model 330P Instruction Manual -- except that the Model 330P must be set for zero external resistance instead of the external resistance marked on the scale.

**Bridge TCB with Electrical Cold Junction**

If the instrument has electrical cold junction compensation and a non-suppressed range:

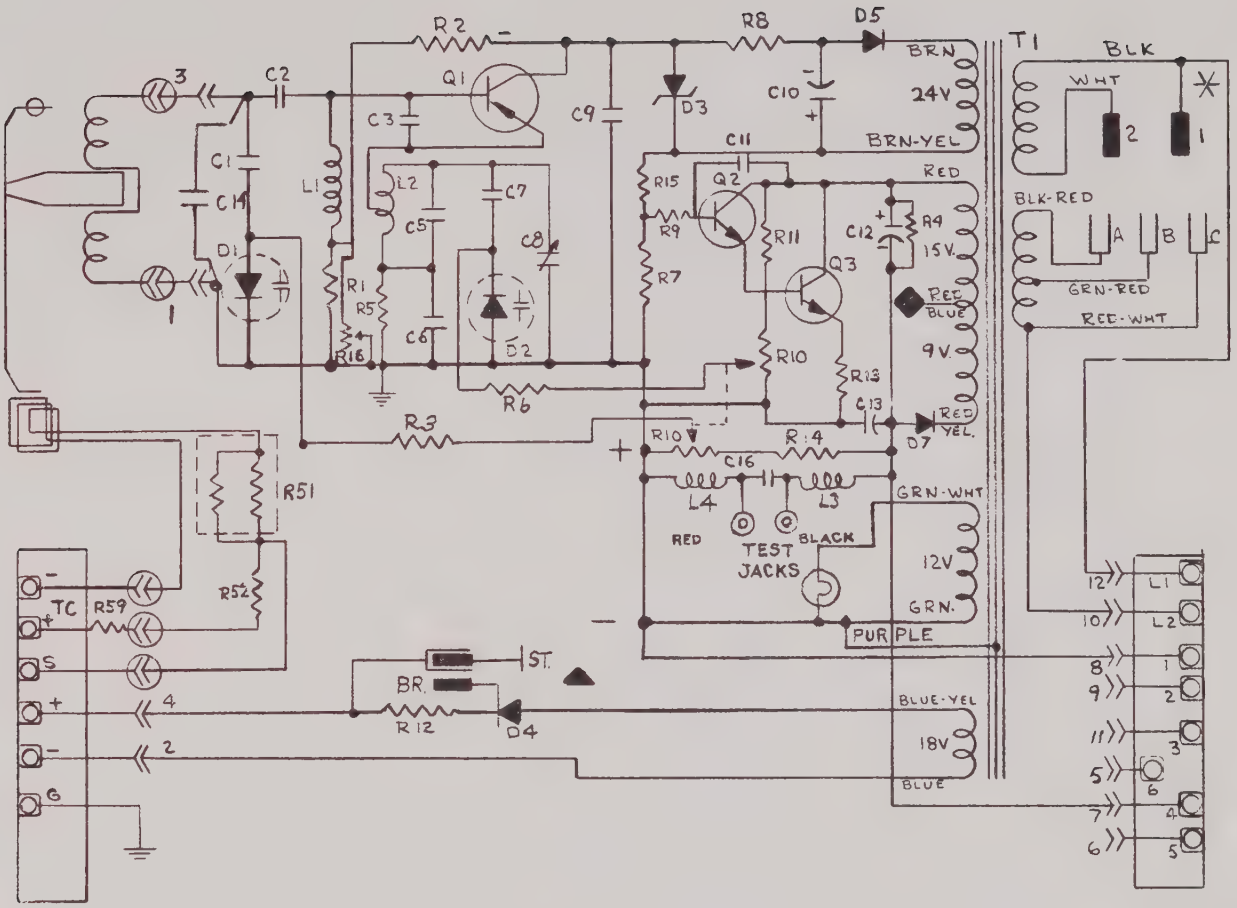
Calibrating procedure is as outlined in the Model 330P Instruction Manual except for the following: The Model 330P must be set for zero external resistance, and for a zero cold junction setting instead of ambient. Since most thermocouple tables are based on 32°F reference temperature, the 0°F millivoltage equivalent has to be added (algebrically) to the desired temperature millivoltage equivalent. For example, the proper 400°F I/C setting on the potentiometer would be:

(0°F) = -0.89 mv, and 400°F = 11.03 mv

11.03 - (-0.89) = 11.92 mv, which is the proper setting

Suppressed range instruments:

These models require a special procedure for calibrating the instrument. Contact your Barber-Colman field office if a calibration check is believed to be necessary.




✳ For 120 v connect A to 1 and C to 2.
For 208 v connect B to 2.
For 240 v connect A to 2.

◆ This connection not used on this model.

▲ Jumper in control chassis:
to pin ST for standard type TCB.
to pin BR for bridge type TCB.

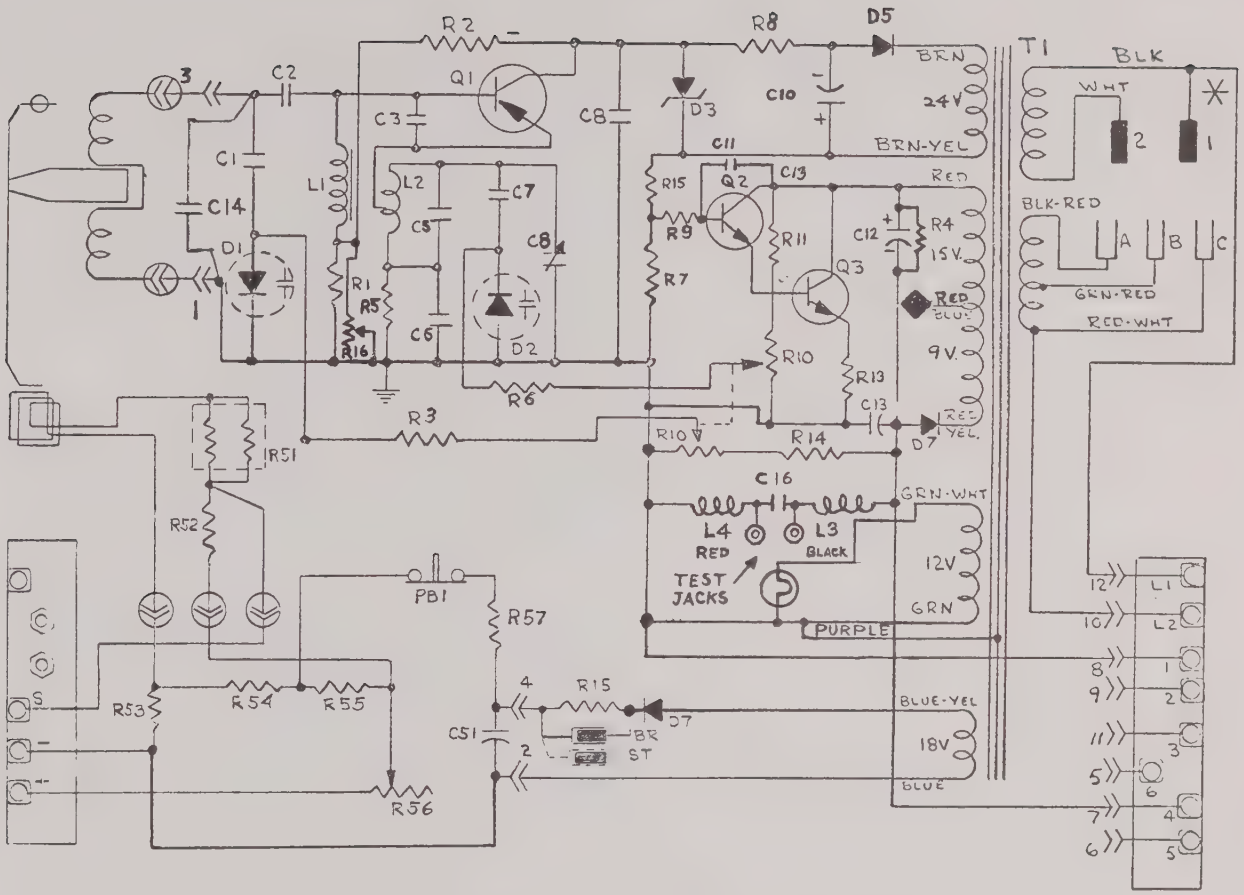
—⟨⟨— Pins on chassis.

—⟨◯⟩— Pins on meter.

◎ Test jack.

Figure 14

Internal Wiring Diagram
Model 477P with Standard TCB




✳ For 120 v connect A to 1 and C to 2.
For 208 v connect B to 2.
For 240 v connect A to 2.

◈ This connection not used on this model.

◢ Jumper in control chassis:
to pin ST for standard type TCB.
to pin BR for bridge type TCB.

—⟨ Pins on chassis.

—⟨◎⟩ Pins on meter.

◎ Test jack.

Figure 15

Internal Wiring Diagram
Model 477P with Bridge Type TCB

Components common to all models in the 477P Series:

| Item | Part Number | Description |
|---|---|---|
| C1 | 39-87 | 62 pfd 500 vdcw ± 5% NPO Capacitor |
| C2 | 39-76 | 250 pfd 500 vdcw ± 20% Capacitor |
| C3 | 39-212 | 8 pfd 500 vdcw ± 10% N4700 Capacitor |
| C5 | 39-87 | 62 pfd 500 vdcw ± 5% NPO Capacitor |
| C6 | 39-76 | 250 pfd 500 vdcw ± 20% Capacitor |
| C7 | 39-87 | 62 pfd 500 vdcw ± 5% NPO Capacitor |
| C8 | 39-160-1 | 2.9-35 pf min. 3.0/2.9 pf max 45/53 pf |
| C9 | 39-103 | .01 mfd 1000 vdcw GMV Capacitor |
| C10 | 39-153 | 50 mfd 50 bdcw -10 +150% Capacitor |
| C11 | 39-228 | .47 mfd 50 vdcw ± 10% Capacitor |
| C12 | 39-163 | 100 mfd 50 vdcw -20 +80% Capacitor |
| C13 | 39-153 | 50 mfd 50 vdcw -20 +80% Capacitor |
| C14 | 39-227 | 25 pfd 500 vdcw N5600 Capacitor |
| C16 | 39-103 | .01 mfd 1000 vdcw GMV Capacitor |
| D1 | 37-60 | Variable Capacitor Diode 33 pf at 4 volts |
| D2 | 37-60 | Variable Capacitor Diode 33 pf at 4 volts |
| D3 | 37-93 | 12 volt Zener Diode 400 mw ± 10% |
| D4 | 37-30 | Silicon Diode 60 piv at 50 ma |
| D5 | EYZP-384 | Silicon Diode 80 piv at 100 ma |
| D7 | EYZP-384 | Silicon Diode 80 piv at 100 ma |
| I1 | 36-34 | 12.6 volt Bulb |
| L1 | 41-133 | 1.2 μh min., 2.7 μh max. Coil |
| L2 | 41-130 | 1.2 μh Coil |
| L3 | 41-124 | 60 μh ± 10% Choke Coil |
| L4 | 41-124 | 60 μh ± 10% Choke Coil |
| Q1 | 31-50 | High Frequency Transistor (2N2188) |
| Q2 | 31-69 | 600 mw Silicon Transistor (2N696) |
| Q3 | 31-69 | 600 mw Silicon Transistor (2N696) |
| R1 | CYZR-133-2 | 1500 Ω ± 10% 1/2 watt Resistor |
| R2 | 40-82 | 33 k Ω ± 10% 1/2 watt Resistor |
| R3 | CYZR-170-18 | 4.7 meg Ω ± 10% 1/2 watt Resistor |
| R4 | CYZR-170-58 | 10 k Ω ± 10% 1/2 watt Resistor |
| R5 | 40-77 | 270 Ω ± 10% 1/2 watt Resistor |
| R6 | CYZR-170-18 | 4.7 meg Ω ± 10% 1/2 watt Resistor |
| R7 | CYZR-170-52 | 560 Ω ± 10% 1/2 watt Resistor |
| R8 | CYZR-133-2 | 1.5 k Ω ± 10% 1/2 watt Resistor |
| R9 | CYZR-105 | 8.2 k Ω ± 10% 1/2 watt Resistor |
| R19A | 29-148 | 100 k Ω ± 10% 1/2 watt Potentiometer |
| R19B | 29-148 | 100 k Ω ± 10% 1/2 watt Potentiometer |
| R11 | 40-70-2 | 47 k Ω ± 10% 1/2 watt Resistor |
| R12 | CYZR-170-9 | 68 k Ω ± 10% 1/2 watt Resistor |

Parts common to all models in the 477P Series (continued):

| Item | Part Number | Description |
|---|---|---|
| R13 | 40-78 | 15 Ω ± 5% 1/2 watt Resistor |
| R14 | 40-70-2 | 47 k Ω ± 10% 1/2 watt Resistor |
| R15 | CYZR-170-32 | 470 Ω ± 10% 1/2 watt Resistor |
| R16 | BYZR-147-1 | 15 k Ω 1/4 watt Potentiometer |
| R51 | A-3049-1 | Temperature Compensator |
| R52 | A-1847 | Multiplier |
| T1 | 30-142 | Power Transformer |
| | 36-34 | 12.6 volt Pilot Lamp |
| | A-5521 | Relay |
| | 30-142 | Power Transformer |

Components unique to the Model 477P with Standard TCB:

| | | |
|---|---|---|
| R59 | A-3497 | External Resistance Compensator |

Components unique to the Model 477P with Bridge Type TCB:

| | | |
|---|---|---|
| R53 | CYZR-326-103 | 5 Ω Resistor |
| R54 | CYZR-326-54 | 2.5 k Ω Resistor |
| R55 | 40-162 | 10 k Ω Resistor |
| R56 | 29-133 | 25 Ω Potentiometer |
| R57 | 40-70-2 | 47 k Resistor |
| C51 | 39-163 | 100 mfd Capacitor |
| PB 32-257 | | SPST NC Push Button Switch |

Components unique to the Model 477P with Bridge Type TCB and Electrical Cold Junction Compensation:

| | | |
|---|---|---|
| D61 | EYZP-384 | Silicon Diode |
| D62 | 37-93 | 12 volt Zener Diode |
| R61 | Consult Factory | |
| R61 | Consult Factory | |
| R62 | CYZR-170-36 | 680 Ω Resistor |
| R63 | A-4409 | 2 k Ω Resistor |
| R64 | 40-175 | 1.6 k Ω Resistor |
| R65 | Consult Factory | |
| R68 | A-4409 | (Specify TC type and scale range |
| R69 | A-4409 | (and consult Factory |
| R70 | A-4409 | ( " |
| R71 | A-4409 | 400 Ω Resistor |

## Suggested Replacement Parts to Keep on Hand

| Quantity | Part Description | Part Number |
|---|---|---|
| 2 | MAZDA Pilot Lamps | 36-34 |
| 1 | Replacement Thermocouple | Barber-Colman can supply thermocouple assemblies, components or wire for any requirement you may have. If need be, delivery will be made in 48 hours. Contact your nearest Barber-Colman field office. |
| 1 | Indicating Meter Assembly | A-6175 |
| 1 | Control Chassis | A-6003 |

We do not recommend electronic component replacement except by well equipped instrument repair shops.

Barber-Colman, Industrial Instruments Division, maintains service and repair facilities in many major cities in the United States and Canada. Consult your yellow pages directory.

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